



## U.S. Department of Energy Energy Efficiency and Renewable Energy

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# INDUSTRIAL TECHNOLOGIES PROGRAM

## Fatigue Resistant Energy Efficient (FREE) Welding

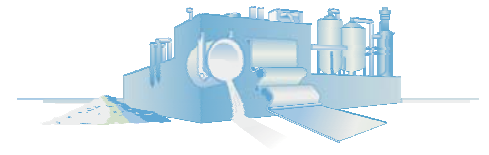
### A program to increase arc welding performance efficiency

Industry partners from Caterpillar, Lincoln Electric, and Ohio State University are leading a project that aims to increase arc welding performance and efficiency by utilizing wave-form-shaping technology. The overall goals of this project are to achieve the capability to weld in multiple orientations with high fatigue strengths; reduce total energy requirements by 35%; improve fabrication weld cycle time by up to 30%; and reduce distortion of fabricated structures by 20%. Synchronization of the robotic weave cycle and pulsed gas metal arc waveform can be used to obtain ideal weld bead shapes with minimum energy input in order to meet program goals. In order to ob-

tain the ideal weld bead shape, an understanding of the process parameters that affect the weld bead geometry will be obtained using statistical methods (design of experiments). The primary focus of this effort pertains to structural steel, high strength low alloy (HSLA) steel, and aluminum structures. Lincoln Electric will provide arc welding equipment and process experience, Caterpillar will provide welding expertise in heavy fabrication and validation testing capabilities, and Ohio State University will provide expertise in the area of experimental design and weld quality management.



*Automated FREE welding*



### Benefits for Our Industry and Our Nation

- Electricity savings of 1 million kWh and 3,400 gallons of diesel fuel per year

### Applications in Our Nation's Industry

The technology will be used in the fabrication of mining technology. Successful commercialization of this technology will significantly reduce arc welding power supply needs.

### Project Partners

Caterpillar

Lincoln Electric

Ohio State University

## Project Description

### Goals:

The objectives of this research are to:

- Develop the ability to integrate robotics with waveform shapes to achieve desired weld bead geometry
- Refine and apply techniques to calibrate models derived from small amounts of laboratory or process data
- Develop process parameter relationships and Pulsed Gas Metal Arc Weld processes for welding of fatigue-critical structures for steel, HSLA and aluminum
- Develop intelligent methods of weld measurement that can accurately predict weld bead geometry from process information

## Progress and Milestones

The project began in January 2004 and is currently investigating three areas: 1) Synergistic Process and Joint Design; 2) In-Process Quality Control Tools; and 3) Validation. Under 1) two general types of weld joints will be investigated: square butt

weld joints and fillet weld joints. Baseline work for square butt joints using current tandem power supplies/torches has started with an experimental matrix and pulsing/non-pulsing combinations of the two torches. A new torch design for this process has been made and is scheduled to be built in the 2nd Quarter (CY) to optimize the ability to weld in narrow gaps. A laboratory is being established to perform robotic-pulsing synchronization development needed for fillet welds. This is scheduled to be established by the end of the 4th Quarter. Under 2) tasks include quality monitoring tools, energy usage models, and statistical design of experimental plans, as well as definition of the data acquisition needs. Acquisition needs are scheduled to be defined by the end of the 2nd Quarter. Under 3) the current fatigue baseline for steels will be compiled and completed early 3rd Quarter. This will be used to evaluate the increased performance of the new welding techniques. Also, a residual stress model for structural steel is planned for 3rd - 4th Quarter, as well as a cost/benefits model to document energy and economic savings.

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## A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

Please send any comments, questions, or suggestions to [webmaster.eren@nrel.gov](mailto:webmaster.eren@nrel.gov)

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